GUIDELINES

GENERAL

There are two purposes for establishing a temporary traffic control zone while working within the highway right-of-way. The first purpose is to provide for the safe and efficient movement of both motorized and non-motorized traffic through or around the work space. The second purpose is to provide protection for workers and equipment located within the work space.

Work in or adjacent to the highway does violate traffic expectations and is performed in vulnerable conditions. However, a properly designed and executed temporary traffic control plan will enable the temporary traffic control zone to provide the above noted functions in the most effective manner possible.

FUNDAMENTAL PRINCIPLES

Motorized and non-motorized traffic and worker safety is an integral and high-priority element of every incident management, maintenance, permit, and utility operation. Consideration of the following principles should enhance the safety performance of the temporary traffic control zone.

- Prepare a temporary traffic control plan and communicate it to all responsible parties prior to occupying the site.
- Provide those whose actions affect the temporary traffic control zone with training appropriate to their level of responsibility.
- Employ the same basic safety principles used to design permanent roadways.
- Avoid frequent or abrupt geometric changes.
- Minimize delay and disruption.
- Schedule and coordinate operations according to *Work Zone Guidelines.*
- Provide adequate warning, delineation, and channelization in advance of and through the area affected.
- Provide positive guidance.
- Provide for safe operation of work.
- Encourage use of alternative routes.

- Assume drivers will only reduce their speeds if they clearly perceive a need to do so.
- Provide for reasonably safe passage of bicyclists and pedestrians.
- Provide recovery areas where practical.
- Coordinate operations with those having jurisdiction over any affected cross streets, railroads, or transit facilities.
- Ensure continuation of emergency services.
- Communicate with and provide reasonable accommodations for adjoining property owners.
- Ensure temporary traffic control devices used are in good working order, reasonably consistent with the temporary traffic control plan, and effective.
- Monitor performance of the temporary traffic control and modify as needed.
- Inspect and maintain temporary traffic control devices.
- Remove, cover, or turn; and turn off all unnecessary temporary traffic control devices.
- Maintain a record of any crashes or incidents.
- Store unused equipment and material in such a manner to reduce the probability of being hit.
- Involve the media to assist in information dissemination.

TEMPORARY TRAFFIC CONTROL ELEMENTS

Temporary Traffic Control Plan

A temporary traffic control plan describes temporary traffic control measures to be used for facilitating the movement of traffic through a temporary traffic control zone. They play a vital role in providing continuity of safe and efficient traffic flow when a work zone or an incident area temporarily disrupts normal traffic flow.

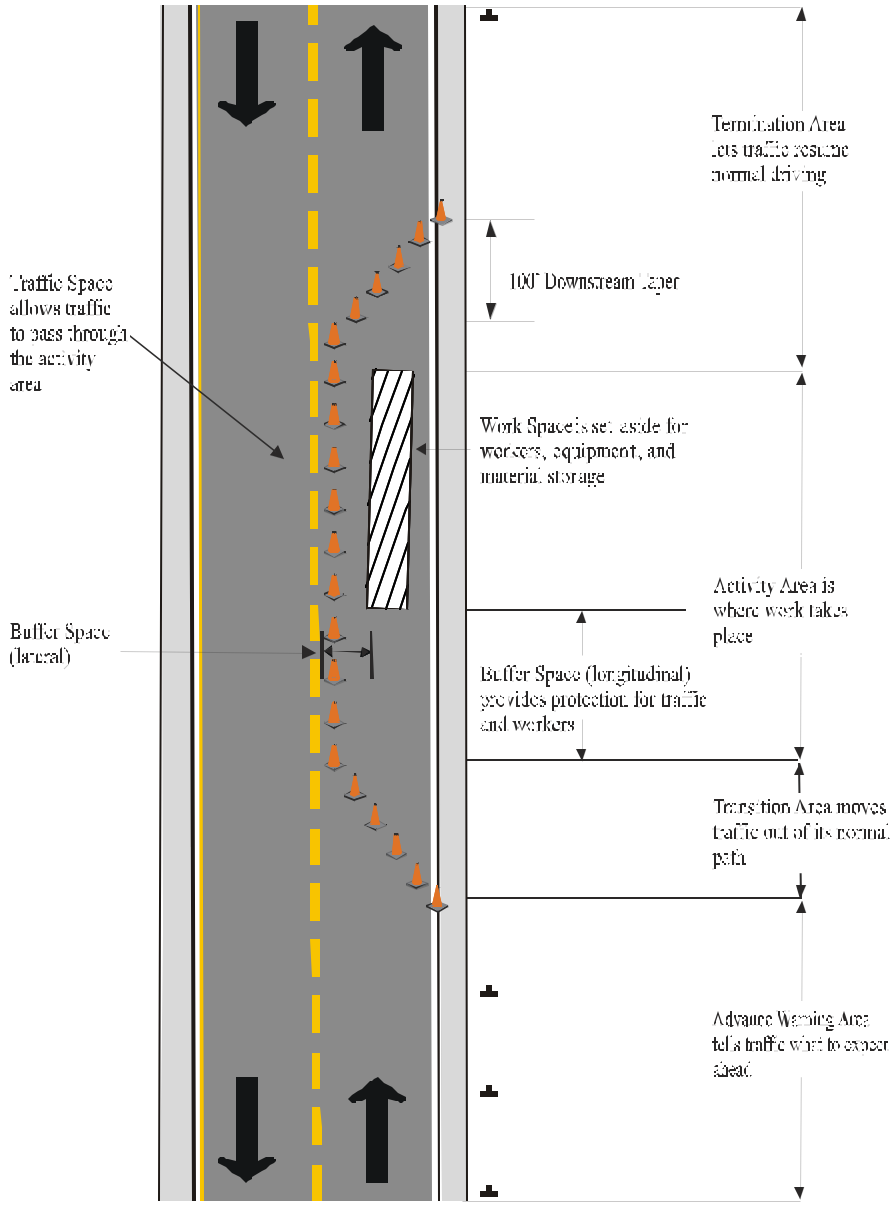
Several temporary traffic control plans, referred to as typical applications, are included in this manual. These plans depict the most common applications of temporary traffic control devices used in highway-related operations.

Temporary Traffic Control Zone

A temporary traffic control zone is a section of highway where traffic conditions are changed due to a work zone or an incident area through the use of temporary traffic control devices, law enforcement, or other authorized officials. It extends from the first warning sign or rotating/strobe lights on a vehicle to the last temporary traffic control device. The zone may either be stationary or move as work progresses.

A temporary traffic control zone consists of four areas - advance warning, transition, activity, and termination.

These areas are illustrated in the following figure.



The **advance warning area** is where traffic is informed of an upcoming temporary traffic control zone. It may vary from a single sign or rotating/strobe lights on a vehicle to a series of signs depending on the duration, location, and type of work.

Recommended sign spacing in this area is shown in the following table.

Speed Limit (mph)	**Sign Spacing[1] (ft.)**	
	Undivided Highway	**Divided Highway**
0-35	200	200
40-45	350	500
50-55	500	1000
60-70	1000	1000
[1] Sign spacing may be adjusted, normally by increasing it, to accommodate field conditions and visibility.		

The **transition area** is where traffic is redirected out of their normal path and into the traffic space. This is usually accomplished through the use of a series of channelizers placed in a taper across the portion of roadway to be closed. There are three types of tapers - shoulder, lane, and one-lane, two-way.

The *shoulder taper* is used to close the shoulder where it is part of the activity area or when improved shoulders might be mistaken for a driving lane.

The *lane taper* is used to close a driving lane by forcing traffic to merge or shift.

Recommended taper length and channelizer spacing for shoulder and lane tapers in the transition area are shown in the following table.

Speed Limit (mph)	**Taper Length[1] (ft.)**		**Channelizer Spacing[4] (ft.)**
	Shoulder[2]	**Lane[3]**	
0-35	70	245	35[5]
40-45	150	540	40[5]
50-55	185	660	50[6]
60-70	235	840	60[6]
[1] Taper lengths may be adjusted to accommodate crossroads, curves, intersections, ramps, or other geometric features. [2] Based on 10 ft. shoulder width. [3] Based on 12 ft. lane width. [4] Channelizer spacing may be reduced to discourage traffic encroachment. [5] Spacing reduced to ½ at intersections. [6] Spacing may be reduced to ½ at intersections.			

The *one-lane, two-way taper* is used to close one lane of a two-lane, undivided highway where the remaining lane is used alternately by traffic in each direction. The taper has a length of 100 feet (5 channelizers @ 20 foot spacing).

Should the highway have an improved shoulder, the taper should be extended to the edge of the roadway at the same spacing. In addition to the channelizers, a flagger, STOP or YIELD sign, pilot car, or temporary traffic control signal controls traffic through this section.

The **activity area** is where work activity takes place. It is comprised of three spaces - work, traffic, and buffer.

The *work space* is the area closed to traffic and set aside for workers, equipment, materials, and a protective vehicle, if one is used upstream. They are usually delineated by channelizers or temporary barriers to exclude vehicles and pedestrians.

The *traffic space* is the area in which traffic is routed through the activity area.

The *buffer space* is the area separating traffic from the work space or an unsafe area. Since this area provides some recovery space for an errant vehicle, it should be kept free of any work activity, equipment, vehicles, and material storage. There are two types of buffer spaces - longitudinal and lateral.

A <u>longitudinal buffer space</u> may be used in advance of the work space or to separate opposing traffic flows using portions of the same traffic lane. When an item such as a protective vehicle is located in this space, only the area upstream of the item functions as the buffer space.

A <u>lateral buffer space</u> may be used adjacent to the work space, an unsafe condition, or between two lanes, especially those carrying traffic in opposite directions. The minimum width of this space is not set but should be determined based on the type of facility, work activity, condition for which the space is being provided, and space available.

Recommended longitudinal buffer length and channelizer spacing in the activity area are shown in the following table.

Speed Limit (mph)	**Buffer Length (ft.)**	**Channelizer Spacing[1] (ft.)**
0-35	120	50[2]
40-45	220	100[2]
50-55	335	100[3]
60-70	550	100[3]

[1] Channelizer spacing may be reduced to discourage traffic encroachment.
[2] Spacing reduced to ½ at intersections.
[3] Spacing may be reduced to ½ at intersections.

The **termination area** is where traffic is returned to their normal path. This area extends from the downstream end of the activity area to the last temporary traffic control device. This area may include a downstream taper or a sign informing traffic they may return to normal operations (e.g. END ROAD WORK or Speed Limit). When a downstream taper is used, the recommended length is 100 feet (5 channelizers @ 20 foot spacing) per lane.

PEDESTRIAN AND WORKER SAFETY

Pedestrian Considerations

While the majority of temporary traffic control situations involve providing safe and efficient movement of motorized traffic, there are times when this function must also be extended to include pedestrians. In these instances, consideration of the following provisions, in addition to those previously noted in Fundamental Principles, should enhance the safe and efficient movement of pedestrians within the temporary traffic control zone.

- Separate pedestrian movements from the activity area and motorized traffic. In some cases it may be necessary to use a physical barrier instead of channelizers to provide this separation.

- Provide a clearly delineated and usable travel path that nearly replicates the existing path.

- Provide advance notification of sidewalk closures to discourage unsafe pedestrian movements.

- Avoid accessing activity area across pedestrian paths.

Worker Considerations

Of equal importance to the safety of the motorized and non-motorized traffic navigating the temporary traffic control zone is the safety of the worker involved in activities within the zone. Therefore, it is important to comply with the following minimum requirements.

- Train field employees involved in the planning, set-up, operation, maintenance or removal of temporary traffic control to the level of their responsibility. For MoDOT employees, this typically requires the completion of both the *Flagger Training* and *Work Zone Technician* courses.

- Require workers to wear the appropriate safety apparel while in the temporary traffic control zone. For MoDOT employees, refer to the department's *Safety Policies, Rules & Regulations Employee Handbook*.

- Inspect and operate vehicles and equipment within the temporary traffic control zone appropriately. For MoDOT employees, refer to the department's *Safety Policies, Rules & Regulations Employee Handbook*.

In addition to the above items and those previously noted in Fundamental Principles, consideration of the following should enhance the safety and effectiveness of the workforce.

- Use physical barriers instead of channelizers to separate traffic from the activity area.

- Reduce speeds through the temporary traffic control zone.

- Use protective vehicles and truck mounted attenuators within the temporary traffic control zone to provide protection from errant vehicles.

- Close the road to traffic temporarily where traffic volumes are low and an adequate alternate route exists.

- Request assistance of law enforcement officials in patrolling the temporary traffic control zone.

- Provide adequate lighting to perform work activities within and guide traffic through the temporary traffic control zone.

- Heighten awareness of the temporary traffic control zone through the use of supplemental warning methods.

- Ensure workers are visible to equipment operators.

- Ensure signal person and equipment operator understand hand signals.

FLAGGER CONTROL

The role of the flagger in temporary traffic control is an important one. It is the flagger's responsibility to assess the safety and efficiency of traffic operations within the temporary traffic control zone and manage the movement of traffic through the proper assignment of right of way and/or by controlling speed. Guidelines for performing this vital function are set forth in the *Flagger Training* course materials. It is good practice for flaggers to review these guidelines on a regular basis in order for them to perform their duties effectively.

Except when performed under emergency conditions, workers engaged in flagging operations on the state highway system shall have successfully completed a recognized

flagger training course. For MoDOT employees, this requires the successful completion of the *Flagger Training* course or an approved substitute.

TEMPORARY TRAFFIC CONTROL DEVICES

General

Temporary traffic control devices are the medium through which traffic is informed of and guided through a temporary traffic control zone or otherwise protected from an unsafe condition. The most common devices include signs, portable changeable message signs, flashing arrow panels, channelizers, barricades, temporary traffic barriers, pavement markings, lighting devices, temporary traffic signals, crash cushions, protective vehicles, and truck mounted attenuators.

Due to the placement of these devices in relation to traffic, these devices shall be crashworthy. This requires that all temporary traffic control devices conform to the crash test requirements of the National Cooperative Highway Research Program (NCHRP) Report 350. Exceptions to this crashworthiness rule are those state-owned devices that have received grandfather status (e.g. pre-10/98 TMAs and pre-10/00 sign stands and barricades).

It may become necessary to ballast some of these devices to inhibit their movement due to natural and vehicle-induced wind in the field. This is particularly the case for portable sign supports and channelizers. Ballast shall be selected and installed such that the ballast itself does not become a hazard if impacted by a vehicle. When in doubt on ballasting, consult the device's manufacturer for their recommendation.

In order for these devices to perform the functions noted previously, they must command the public's respect. This means the correct devices are installed according to the temporary traffic control plan and they function as intended. Furthermore, the devices are maintained throughout the life of the operation and removed when no longer needed. Devices that are damaged or have lost their functionality should be replaced or, when acceptable, repaired. Refer to ATSSA's *Quality Standards for Work Zone Traffic Control Devices* for guidelines regarding acceptability of devices.

Signs

Temporary traffic control signs convey, in words and symbols, both general and specific messages used by motorized and non-motorized traffic to navigate the temporary traffic control zone safely and efficiently. Therefore, it is important all permanent and temporary signs not applicable to conditions present in the temporary traffic control zone be removed, covered, or turned away from the roadway so they are not visible to traffic.

Sign Classification

Temporary signs are classified into one of three types - regulatory, warning, or guide.

Regulatory signs give notice of traffic laws or regulations and indicate applicability of legal requirements that would not be readily apparent. These signs are generally rectangular in shape and have a black legend on white background. Noteworthy exceptions to this rule are the STOP, YIELD, DO NOT ENTER, and WRONG WAY signs. For additional information on regulatory signs, refer to Chapter 11 of the Signing section of the *Traffic Manual*.

Warning signs give notice to situations or conditions that might not be readily apparent. These signs are generally diamond-shaped and, when used in a temporary traffic control zone, have a black legend or symbol on orange background. For additional information on standard and temporary warning signs, refer to Chapters 12 and 13 of the Signing section of the *Traffic Manual*, respectively.

Guide signs indicate route designations, destinations, directions, distances, services, points of interest, or other geographical, recreational, or cultural information. These signs come in different shapes and colors depending on type and purpose of the signing. However, special guide signs relating to the conditions of the temporary traffic control zone (e.g. RAMP OPEN, DETOUR, ROAD WORK NEXT XX MILES, etc.) are typically rectangular in shape and have a black legend on orange background. For additional information on temporary and standard guide signs, refer to Chapters 13 and 15 of the Signing section of the *Traffic Manual*, respectively.

Sign Design

Details, descriptions, and ordering information for signs used for temporary traffic control are specified in the Signing Section of the *Traffic Manual*, as noted in the preceding section.

These signs may have a rigid or flexible substrate. However, the two sign materials are not necessarily interchangeable. Each should be used on a sign support for which the sign system (i.e. the sign and support) has been designed. This is especially true when trying to meet crashworthiness requirements.

Flashing warning lights and/or flags may be used to supplement these signs provided they do not block the sign face.

Sign Installation

Signs used for temporary traffic control are placed on the right side of an undivided highway and on both sides of divided highways unless otherwise specified in this manual. Where space exists, signs may also be placed on the left side of multi-lane, undivided highways. Signs should not be located where they will conflict with the

movement of non-motorized traffic or where visibility of them will be limited by field conditions.

Recommended sign spacing is shown in the following table.

Speed Limit (mph)	Sign Spacing[1] (ft.)	
	Undivided Highway	Divided Highway
0-35	200	200
40-45	350	500
50-55	500	1000
60-70	1000	1000
[1] Sign spacing may be adjusted, normally by increasing it, to accommodate field conditions and visibility.		

Signs may be supported in one of four methods - on a portable support, break-away post, vehicle, or traffic barrier.

Portable signs are temporary traffic control signs affixed to a portable support such as a self-driving post, easel, fold-up sign stand, barricade, etc..

These signs are be constructed of either a rigid or flexible substrate, as required, to meet crashworthiness requirements.

A minimum mounting height of one foot, measured vertically from the bottom of the sign to the near edge of the pavement, is recommended. However, higher mounting heights should be considered on higher volume highways, on multi-lane highways, in urban settings, and where the sign is located in line with other traffic control devices to increase visibility of the sign. Mounting heights for critical regulatory and guide signs (e.g. STOP, YIELD, DO NOT ENTER, WRONG WAY, ONE WAY and Gore Exit) are as specified for post-mounted signs.

Portable signs may be located adjacent to or within the roadway itself. However, a minimum lateral clearance of three feet, measured horizontally from the edge of the sign to edge of the designated traveled way, is recommended.

Signs mounted in this manner may be left in place for up to three days. An exception to this duration is any crosswalk/sidewalk closure, any road closure, Horizontal Arrow, Double-Headed Horizontal Arrow, Chevron, DETOUR (within arrow), or Gore Exit sign. These sign may be left in place for over three days.

When not in use, consideration should be given to removing portable signs from the temporary traffic control zone to discourage theft and limit potential hazards within the right-of-way.

Post-mounted signs are temporary traffic control signs affixed to a breakaway support such as perforated square steel tube, u-channel, wood, etc..

These signs are constructed of a rigid substrate.

A minimum mounting height of seven feet, measured vertically from the bottom of the sign to the near edge of the pavement, is recommended for urban highways and rural divided highways. A minimum mounting height of five feet, measured vertically from the bottom of the sign to the near edge of the pavement, is recommended for rural undivided highways. If a supplemental sign is mounted below another sign, the mounting height of the supplemental sign may be one foot less than the heights specified.

A minimum lateral clearance of two feet, measured horizontally from the edge of the sign to the edge of the roadway, is recommended for installations on roadways with curbed sections. A minimum lateral clearance of six feet, measured horizontally from the edge of the sign to the edge of the traveled way, is recommended for installations on roadways without curbed sections.

Vehicle-mounted signs, when allowed in this manual, are temporary traffic control signs affixed to a protective vehicle or pilot car at a recommended minimum height of four feet, measured vertically from the bottom of the sign to the pavement surface.

Barrier-mounted signs are temporary traffic control signs affixed to the top portion of a temporary or permanent traffic barrier. The method of attachment to the barrier must assure a positive connection and minimize potential for vehicle snagging. Mounting heights for critical regulatory and guide signs (e.g. STOP, YIELD, DO NOT ENTER, WRONG WAY, ONE WAY and Gore Exit) are as specified for post-mounted signs.

In order to accommodate narrow medians, it may be necessary to reduce the sign size; clip the sign corners or edges; or possibly both.

Portable Changeable Message Signs

Portable changeable message signs are temporary traffic control devices with the flexibility to display a variety of messages. These messages provide pertinent traffic operation and guidance information to the motorist. They serve as a supplement to, not as a replacement for or a repeat of, static temporary traffic control signing. In temporary traffic control applications, these units are generally mounted on a trailer.

Some typical situations where portable changeable message sign use may be beneficial to temporary traffic control are as follows.

- Where the speed of traffic is expected to drop substantially.
- Where significant queuing and delay are expected.
- Where adverse environmental conditions exist.

- Where there are changes in alignment or surface conditions.
- Where there is a ramp, lane, or roadway closure.
- Where a crash or incident has occurred.
- Where traffic patterns change.

Messages should consist of a maximum of two phases. Typically, these phases consist of three lines of eight characters. Techniques such as fading, exploding, dissolving, moving, or scrolling text shall not be used. The entire message cycle should be readable to traffic at least twice while traveling at the posted speed. Messages should be programmed prior to deployment of the unit to the field. Consideration of the following guidelines will assist in designing a message.

- Each phase should convey a single thought.
- If the message can be displayed in one phase, the top line should present the problem, the center should present the location or distance ahead, and the bottom line should present the recommended driver action.
- The message should be as brief as possible.
- When a message is longer than two phases, additional portable changeable message signs should be used.
- When abbreviations are used, they should be easily understood.

Signs should be located to provide traffic with ample warning of any conditions ahead or actions they may need to perform.

It is preferable to locate signs off to the right of any usable portion of the roadway. Where field conditions do not allow for this placement, the signs may be located on the outside shoulder of the roadway or within the median where field conditions do not allow for deployment on the outside shoulder. A minimum lateral clearance of three feet, measured horizontally from the edge of the sign to edge of the traveled way, is recommended.

If multiple signs are used, the signs should be located on the same side of the road and separated according to the sign spacing chart.

A minimum mounting height of seven feet, measured vertically from the bottom of the sign to the roadway, is recommended.

When deployed, the sign shall be sighted and aligned with approaching traffic to ensure visibility of the message.

Five channelizers should be used to delineate each sign. These channelizers should be positioned on the upstream end of the unit to form a taper leading up to traffic side of the unit. The recommended length of this taper is 100 feet. For a sign located in the median, the sign should be delineated from both directions.

Flashing Arrow Panels

Flashing arrow panels are temporary traffic control devices with a matrix of elements capable of flashing displays. The devices are intended to provide additional warning and directional information to assist in traffic movement through or around a temporary traffic control zone. These units may be either trailer- or truck-mounted. However, truck-mounted units are preferred in mobile operations.

The overall minimum dimensions of the panels are 60 inches wide by 30 inches high for truck-mounted units and 96 inches wide by 48 inches high for trailer-mounted units. Panels for both units shall include 15 yellow elements.

Panels may be operated in one of three operating modes - arrow, double arrow, and caution. The arrow and double arrow modes are used for stationary or moving lane closures on multi-lane highways. The arrow mode is used when traffic has no choice but to go left or right while the double arrow mode is used when traffic has the choice to go left or right. The caution mode is used for shoulder work, blocking the shoulder, work within a lane where the lane is not closed, and lane closures on two-lane, undivided highways. When used during night operations, these displays shall be dimmed by 50 percent.

For stationary lane closures, the panel should be deployed on the shoulder or within an adjacent closed lane at the beginning of the lane or one-lane, two-way taper. Where adequate space or the temporary traffic control plan does not permit this placement, the unit may be placed within the taper of the closed lane. When closing multiple lanes, a separate unit shall be used to close each lane.

For moving lane closures on two-lane, undivided highways, the panel shall be deployed within the lane to be closed.

For moving lane closures on multi-lane highways, one panel should be deployed on the shoulder and another shall be deployed within the lane to be closed. Where adequate space does not permit deployment of the unit on the shoulder, the unit may be positioned partially in the lane to be closed. When an interior lane is being closed by itself, both units shall be deployed within the lane to be closed. When closing multiple lanes, a separate unit shall be used to close each lane.

A minimum lateral clearance of three feet, measured horizontally from the edge of the panel to the edge of the traveled way, is recommended for trailer-mounted units deployed as specified in the previous paragraphs.

A minimum mounting height of seven feet, measured vertically from the bottom of the panel to the roadway, is recommended for trailer-mounted units. For Truck-mounted units, the panel mounting height should be as high as practical.

When deployed, the panel shall be sighted and aligned with approaching traffic to ensure visibility of the display.

Except when panels are located behind a taper or are truck-mounted, five channelizers should be used to delineate each panel. These channelizers should be positioned on the upstream end of the unit to form a taper leading up to traffic side of the unit. The recommended length of this taper is 100 feet.

Channelizers

The function of channelizers is to warn motorized and non-motorized traffic of conditions created by temporary activities or conditions in or near the roadway and to guide them through or around these conditions. Uses for these devices include the following.

- Provide smooth and gradual traffic flow from one lane to another, onto a bypass or detour, or into a narrower traveled way.
- Separate traffic from the activity area, pavement drop-offs, opposing traffic, or non-motorized traffic.
- Separate non-motorized traffic from the activity area or unsafe conditions.
- Delineate spot obstructions
- Supplement other traffic control devices.

There are four types of channelizers used to perform these functions – cones, drums, trim-line channelizers, and direction indicator barricades.

Cones are conical-shaped devices that are orange in color and 28 inches in height. For nighttime operations, they are augmented with bands of retroreflective white sheeting to improve their visibility.

Drums are cylindrical-shaped devices that are orange in color, 36 inches in height, a minimum of 18 inches in diameter, and augmented with alternating bands of orange and white retroreflective sheeting.

Trim-line channelizers are conical-shaped devices that are orange in color, 42 inches in height, eight inches in diameter at the base, and augmented with alternating bands of orange and white retroreflective sheeting.

These devices are particularly effective in areas like ramps and intersections or where there is limited lateral clearance. In these situations, they provide greater warning and delineation functions than cones while maintaining a smaller footprint than drums.

Direction indicator barricades are 36 inch tall devices consisting of a 24 inch wide by 12 inch tall retroreflective orange panel with a horizontal arrow on top and a 24 inch wide by eight inch tall panel of alternating orange and white retroreflective stripes at a 45-degree angle on bottom.

These devices may be used in lieu of other channelizers for tapers in the transition area. When used, the arrow on the top panel and the stripes on the bottom panel shall point toward and slope downward, respectively, to the side of the unit in which traffic is to pass.

Recommended channelizer spacing is shown in the following table.

Speed Limit (mph)	**Channelizer Spacing[1] (ft.)**	
	Taper	**Buffer/Work Areas**
0-35	35[2]	50[2]
40-45	40[2]	100[2]
50-55	50[3]	100[3]
60-70	60[3]	100[3]

[1] Channelizer spacing may be reduced to discourage traffic encroachment.
[2] Spacing reduced to ½ at intersections.
[3] Spacing may be reduced to ½ at intersections.

Barricades

A barricade is a portable device used to close, restrict, or delineate all or a portion of the right-of-way to motorized and non-motorized traffic. Each unit contains a number of rails augmented with stripes of alternating orange and white retroreflective sheeting on the side facing traffic.

Where a barricade extends entirely or partially across a roadway, the stripes should slope downward at a 45-degree angle across the entire barricade array in the direction in which traffic is to pass. Where both right and left movements are provided, the stripes should slope downward at a 45-degree angle away from the center of the barricade array. Where no movements are provided, the stripes should slope downward at a 45-degree angle toward the center of the barricade array.

The Type I (one rail) and Type III (three rail) barricade configurations are used on the state highway system. The Type III barricade is the preferred option to perform the previously noted operations. The Type I barricade is acceptable for use in non-motorized traffic operations on all highways and in emergency road closures on two-lane, undivided highways.

When a roadway is closed, but access is still allowed for local traffic or work vehicles, barricades may be offset to facilitate movement into and out of the closed area.

Temporary Traffic Barrier

Temporary traffic barrier may be used in lieu of or in addition to channelizers separating motorized traffic from the work space, an unsafe condition, or non-motorized traffic. It is not used to form tapers.

Due to the amount of resources needed to put barrier in place, this option is generally reserved for long-term stationary operations where the need for the noted functions is critical.

If barrier is desired, consult with appropriate engineering staff for design requirements prior to installation.

When used, barrier should be supplemented with delineation for increased visibility. This delineation shall match the applicable pavement marking color.

Any end of the barrier installation susceptible to being hit by vehicular traffic shall be protected with a crashworthy end treatment. This requires installation of a barrier height transition for speeds less than or equal to 35 mph or an approved crash cushion for speeds greater than or equal to 40 mph. As an option, barrier may be flared at a rate of 8:1 back to the limits of the clear zone, backslope, or curb provided the side slope is 6:1 or flatter.

Pavement Markings

Under normal operating conditions, pavement markings are great means of channelizing and providing guidance to traffic. However, when temporary traffic control activities change the normal operation of a roadway, existing pavement markings, like permanent signing, can confuse the motorist.

For long-term operations, permanent pavement markings should be removed or obliterated and temporary pavement markings installed when markings are not applicable to the temporary condition as soon as practical. For operations of shorter duration, the other temporary traffic control devices (e.g. channelizers, signs, etc.) deployed will be relied on to provide traffic with the needed channelization and guidance cues. Pavement marking revisions for shorter duration operations are also a possibility, but should be considered on a case-by-case basis.

When pavement marking revisions are necessitated by a temporary traffic control operation, the following guidelines shall be employed.

- Temporary markings shall be in accordance with Section 3 of the Marking section of the *Traffic Manual.*

- All markings should be maintained throughout the duration of the operation. Temporary markings should be maintained until permanent markings are installed.

- Temporary markings shall match those at both ends of the temporary traffic control zone.

- Temporary markings shall be in place prior to opening a roadway to traffic.

- Removal or obliteration of all markings shall be thorough and leave minimal pavement scarring.

- Concealing any marking with black paint or asphalt is not acceptable.

Lighting Devices

There are two purposes for providing lighting devices in temporary traffic control zones. The first purpose is to illuminate a portion of the roadway in order to safely and effectively perform work activities or to highlight areas requiring increased driver attention. This is accomplished through work and area lighting, respectively. The second purpose is to supplement other temporary traffic control devices or to identify work vehicles and equipment. This is accomplished through warning and fleet lighting, respectively.

Work lighting enhances worker safety and quality of the work performed during nighttime operations by illuminating the work area to a level at which workers can adequately see what they are doing. A minimum intensity of five footcandles is recommended to satisfy this objective. Typically, this lighting is provided by an array of vehicle- or equipment-mounted floodlights, an array of floodlights on a portable lighting unit, or an internally illuminated balloon. Lighting shall be positioned such that it does not cause glare for motorists, spill onto adjacent properties, create shadows within the work space, or become a safety concern.

Area lighting illuminates specific areas significant to traffic guidance within the temporary traffic control zone during nighttime hours. Lighting of this nature is required at flagger stations and may be considered at gore areas, transitions, ingress and egress areas, equipment crossings, intersections, and temporary signals. A minimum intensity of 0.6 footcandles in the specific area is recommended for this type of lighting. Typically, this lighting is provided by a single light on a portable lighting unit

or mounted on a temporary pole. As with work lighting, lighting shall be positioned such that it does not cause glare for motorists, spill onto adjacent properties, create shadows, or become a safety concern.

Warning lights are an option available to increase the target value of other temporary traffic control devices. Typically, a single self-contained unit that emits a yellow light is used for this type of lighting. There are three types of warning lights - A, B, and C.

> *Type A warning lights* are low-intensity, flashing light units capable of being visible from a distance of 3000 feet on a clear night. These units may be used during nighttime hours to warn motorists they are approaching or proceeding through a potentially hazardous area. Their use is limited to supplementing other traffic control devices throughout the temporary traffic control zone. They are not be used for delineation.
>
> *Type B warning lights* are high-intensity, flashing light units capable of being visible from distance of 1000 feet on a sunny day with the sun directly on or behind the device. These units may be used during both daytime and nighttime hours to warn motorists they are approaching a potentially hazardous area. Their use is limited to supplementing signs in the advance warning area and other temporary traffic control devices at point locations throughout the temporary traffic control zone. They are not be used for delineation.
>
> *Type C warning lights* are steady-burn light units capable of being visible from a distance of 3000 feet on a clear night. These units may be used during nighttime hours to delineate the intended path. Their use is limited to supplementing a traffic control device in a lane taper; one-lane, two-way taper; diversion, curve, and other similar condition. Note: When used to help delineate curves, light units shall only be placed on the outside of the curve.

Warning lights shall be mounted at a minimum of 30 inches, measured from the base of the host device to the bottom of the unit, exclusive of any housing. In addition, lights should be installed so they do not hinder the functionality of the device they supplement or become a hazard themselves.

Fleet lighting increases the visibility of work or incident response vehicles and equipment while in the temporary traffic control zone. All work vehicles and equipment shall be equipped with an acceptable warning light system. These lights shall be activated whenever a vehicle or piece of equipment is engaged in a work zone or incident response operation within the temporary traffic control zone. An exception to this requirement is those vehicles and pieces of equipment located within a work space delineated by channelizers or protected by temporary traffic barrier. For this situation, activation of the lights is not required. Standard hazard warning lights may be used as a supplement to, but not as a replacement for, fleet lighting.

Temporary Traffic Control Signals

Temporary traffic control signals are used at haul road or equipment crossings, on one-lane, two-way operations, and at temporary intersections located within the temporary traffic control zone to assign vehicular right of way. Typically, this is done with temporary span-wire installations or trailer-mounted units.

Consideration of the following factors will assist in the design and application of a signal installation.

- Site characteristics (e.g. safety and traffic needs; traffic volumes and speeds; sight distance and turning restrictions; side streets and driveways; parking; pedestrians; existing traffic control devices; human factors; etc.)

- Temporary traffic control design details (e.g. work staging; operation location and duration; feasibility of using other temporary traffic control measures; placement of this and other temporary traffic control devices; etc.)

- Functional aspects (e.g. signal phasing and timing requirements; full-time or part-time operation; actuated, fixed-time, or manual operation; interconnection with other temporary or permanent signals; etc.)

- Operational issues (e.g. power source; operation, inspection, and maintenance needs; record keeping; etc.)

When used, signals shall be installed and operated in accordance with the Signals section of the *Traffic Manual.* In addition, the signals shall meet the physical display and operational requirements of conventional signals.

A traffic engineer or their designee shall approve all timing of the signal. In one-lane, two-way situations, this timing shall include an all-red interval of sufficient duration for traffic to clear the portion of roadway controlled by the signal.

A minimum lateral clearance of three feet, measured horizontally from the edge of the trailer to the edge of the traveled way, is recommended for trailer-mounted units.

When deployed, signal heads shall be properly aligned with approaching traffic to ensure visibility of the indications.

Five channelizers should be used to delineate each trailer-mounted signal. These channelizers should be positioned on the upstream end of the unit to form a taper leading up to traffic side of the unit. The recommended length of this taper is 100 feet.

Crash Cushions

Crash cushions are systems that mitigate the effects of errant vehicles impacting roadside obstacles such as fixed objects or exposed barrier and guardrail ends. The system is designed to accomplish this by either smoothly decelerating the vehicle to a stop or redirecting the vehicle.

Due to variability of site conditions, systems shall be selected on a case-by-case basis. Consult appropriate engineering staff for this assistance.

Protective Vehicles

Protective vehicles are used to safeguard the work space from errant vehicles. In some operations, these devices also serve as platforms for signs and other devices used to warn traffic of upcoming conditions or inform them of needed actions. For increased motorist, driver, and worker safety, the protective vehicle may be equipped with a truck-mounted attenuator as noted in the following section.

Protective vehicles should provide sufficient warning to approaching traffic and maximum protection to workers and equipment. This implies the protective vehicle be positioned so that it is clearly visible to approaching traffic, minimizes any vehicular encroachment into the area between the protective vehicle and the work space, and maintains a recommended minimum of 150-foot clear roll ahead distance between the vehicle and the work space.

The wheels of the protective vehicle should be aligned with traffic at all times. In addition, the emergency brake shall be set and the transmission put into neutral in stationary operations.

Truck-Mounted Attenuators

Truck-mounted attenuators are energy-absorbing devices attached to the rear of trucks used as protective vehicles. These devices are designed to protect the motorist and protective vehicle driver upon impact.

In general, the guidelines for the use of these devices are shown in the following table.

Highway Type	Operation Location and Duration		
	In Lane		On Shoulders and Ramps and at Intersections
	Mobile	Stationary	
Two-Lane Undivided	Recommended	Recommended	Recommended
Multi-Lane Undivided	Required	Recommended	Recommended
Multi-Lane Divided	Required	Required	Recommended

Supplemental Warning Methods

It may, on occasion, be desirable to enhance the target value of certain temporary traffic control devices or the entire zone. The purpose of this is to increase awareness of the temporary traffic control zone or specific conditions within it.

Typical methods for accomplishing this objective include supplementing the prescribed devices with other devices, adding devices to the zone, or changing the characteristics of a device itself. Examples of possible enhancements are as follows.

- Cones by signs or at flagger stations
- Flags atop signs
- Increased sign height
- Additional signs
- More or increased levels of retroreflectivity
- Warning lights on devices
- Area lighting
- Portable changeable message signs
- Pavement markings
- Speed trailers
- Light bars on vehicles
- Law enforcement
- Press releases

TEMPORARY TRAFFIC CONTROL ZONE OPERATIONS

Duration of Work

Work duration is a major factor in determining the number and types of devices used in temporary traffic control zones. The duration of a temporary traffic control zone is defined relative to the length of time an operation occupies a location. There are six categories of work duration - long-term stationary, intermediate-term stationary, short-term stationary, short duration, mobile and emergency.

Long-term stationary operations include planned work occupying a location more than three days.

Post-mounted signs, larger channelizers and barricades, temporary traffic barriers, temporary pavement markings, work lighting, area lighting, warning lighting, and temporary traffic signals are devices generally incorporated into the temporary traffic control plan for these operations. In addition to providing a greater margin of safety, these types of devices provide superior operational characteristics - an important consideration during nighttime hours and periods when workers are not present.

Intermediate-term stationary operations include planned daytime work occupying a location from more than one daylight period up to three days or planned nighttime work occupying a location more than 30 minutes.

In these operations the same procedures and devices used in long-term stationary operations may be desirable. However, their use should be carefully considered, as they may not be feasible or practical to deploy. The increased time to place and remove these devices in some cases could significantly lengthen the project, thus increasing exposure time.

Short-term stationary operations include planned daytime work occupying a location for more than 30 minutes, but less than twelve hours. This category describes the majority of work zone activities undertaken on the state highway system.

In these operations, procedures and devices are usually simplified when compared to intermediate- and long-term stationary operations because workers are present to maintain and monitor the temporary traffic control zone, the zone is only set up during daylight hours, and it is only in place for a relatively short period of time. Portable signs, flashing arrow panels, channelizers, fleet lighting, protective vehicles, and truck-mounted attenuators are devices generally incorporated into the temporary traffic control plan for these operations.

Short duration operations include planned daytime or nighttime work occupying a location up to 30 minutes.

These operations might involve different types of temporary traffic control devices since it often takes longer to set up and remove the temporary traffic control than it does to perform the actual work. Vehicle-mounted signs, truck-mounted flashing arrow panels, fleet lighting, protective vehicles, channelizer cones, and truck-mounted attenuators are typical devices considered for use in these types of operations.

Mobile operations include planned work that moves intermittently or continuously.

These operations often involve frequent, short stops for activities where workers are on foot. These stops can last up to 15 minutes in duration. Typical work activities include litter cleanup and pothole patching.

Due to the similarity of these activities to short duration operations, the same procedures and devices considered for use in short duration operations are also desirable for use in these types of mobile operations. When non-mobile devices like portable signs are used, they should be moved periodically to keep them near the operation.

Mobile operations also include work activities in which workers and equipment move along the roadway without stopping. Typical work activities include mowing, snow removal, spraying, sweeping, and long-line striping.

In these types of activities the advance warning area moves with the operation. Therefore, total mobility of the temporary traffic control zone is important and devices should be chosen accordingly. In some continuously moving operations, a work vehicle equipped with fleet lighting may be sufficient. In others, a protective vehicle equipped with fleet lighting, a truck-mounted attenuator, a flashing arrow panel, and a sign may be needed. Where work proceeds at unusually slow speeds, less than five miles per hour, it may be desirable to place warning signs along the roadway and move them periodically as work progresses.

Emergency operations include unplanned work occupying a location up to 15 minutes. Within MoDOT, these operations consist of the initial response to and repair/removal of safety concerns as defined by Response Priority 1 items (refer to the *Risk Management Manual, Claims Administration Section*).

In these operations, it is usually more advantageous, from a safety standpoint, to remove or provide warning of the risk in a timely manner with limited temporary traffic control than it is to set up a temporary traffic control zone for short duration operations. The decision to reduce the temporary traffic control shall be at the discretion of the supervisor. However, work activities shall still be performed with the safety of the motorist and worker in mind. A vehicle-mounted sign, truck-mounted flashing arrow panel, and fleet lighting are devices generally incorporated into the temporary traffic control plan for these operations. A protective vehicle and truck-mounted attenuator should be considered as additional safety measures.

Location of Work

In addition to work duration, work location is also a major factor in determining the temporary traffic control needed for a temporary traffic control zone. As a general rule, the closer the work activity is to traffic, the greater the need for and number of temporary traffic control devices. Typically, the degree of temporary traffic control is based on three locations - work beyond shoulder, work on shoulder, and work within the traveled way.

Work beyond shoulder includes any work performed between the edge of the shoulder, the edge of the traveled way where no shoulder exists, to the right-of-way line or within any unimproved median.

Work performed in this area typically requires a minimal amount of temporary traffic control, such as signs and fleet lighting, or even none at all. The amount and type of temporary traffic control depends on the lateral displacement of the work activity and the location and movement of any work vehicle or equipment relative to the edge of the shoulder, or traveled way where no shoulder exists.

Work on shoulder includes any work performed on the shoulder that does not significantly encroach upon the adjacent driving lane. Where no shoulder exists, this

also includes any work performed adjacent to the roadway that encroaches, but not significantly, upon the adjacent driving lane. A significant encroachment means ten feet of driving surface cannot be maintained for traffic.

Temporary traffic control devices typically required for work performed in this area consists of signs and fleet lighting up to a full array of devices depending on work duration.

Work within the traveled way includes any operation requiring a lane closure.

Due to the location of the operation, more temporary traffic control devices are required to ensure the safety of both the motorist and the worker. Mobile operations typically require a vehicle-mounted sign, flashing arrow panel, fleet lighting, protective vehicle, and truck-mounted attenuator. Stationary operations usually require the substitution of multiple stationary signs for the single vehicle-mounted sign and the addition of channelizers and flaggers.

MISCELLANEOUS TEMPORARY TRAFFIC CONTROL ITEMS

Work Zone Length

While it is important to grab the motorist's attention as they approach the temporary traffic control zone, it is just as important to maintain their attention as they travel through the zone. To accomplish this, the work zone length, including any areas of inactivity within this length, should be kept to a minimum.

The work zone length is defined as the distance from the last sign in the advance warning area to the last temporary traffic control device in the same direction or to the last sign in the advance warning area in the opposing direction, whichever is longest.

The recommended maximum work zone length is shown in the following table.

Highway Type	Work Zone Length
Urban	1 mile
Rural Divided	2 miles
Rural Undivided	3 miles

Speed Limits

The Missouri Department of Transportation has the authority to set speed limits on the state highway system. This power extends to establishing speed limits in temporary traffic control zones, where the speed limit may be reduced from the normal speed limit for safety purposes.

A reduced speed limit should be carefully considered before it is imposed, as motorists will only reduce their speed if they perceive a need to do so. Any decision to reduce the speed limit based on an arbitrary, 'across the board', or other inappropriate rationale may result in non-compliance with the reduced speed limit by motorists and a false sense of security for workers.

Should a reduced speed limit be deemed appropriate, the following table shows the recommended maximum speed reductions or the minimum speed that may be imposed in temporary traffic control zones.

Highway Type	**Posted Speed Limit**	**Activity (i.e. Workers, Equipment, or Material) Location from Edge of Traveled Way**	**Work Area Protection**	
			Protected[1]	**Unprotected**[2]
Multi-lane	> 55 mph	> 30 ft.	Posted	
		≤ 30 ft.	Posted	Posted-10
		In Traffic Lane	Posted-10	Posted-20
	≤ 55 mph	> 10 ft.	Posted	
		≤ 10 ft.	Posted	Posted-10
		In Traffic Lane	Posted-10	
Two-Lane/ Two-Way	> 55 mph	> 10 ft.	Posted-10	
		≤ 10 ft.	Posted-10	Posted-20
		In Traffic Lane	35 mph	
	≤ 55 mph	> 10 ft.	Posted	
		≤ 10 ft.	Posted	Posted-10
		In Traffic Lane	35 mph	

[1] A "Protected" activity is one physically shielded by a crashworthy device (e.g. temporary traffic barrier, guardrail, etc.).
[2] An "Unprotected" activity is one not shielded by crashworthy device (see previous note), but may only be delineated by channelizers or pavement markings.

After selecting a reduced speed limit based upon the table above, the following guidelines will assist in the proper installation and application of that reduced speed limit in the temporary traffic control zone.

- If roadway geometrics (e.g. temporary by-pass, narrow lane, etc.) during the work activity require a lower speed limit than the one shown in the table above, then the speed shall be based on geometrics. However, no speed limit shall be reduced below 35 mph.

- When the reduced speed applies to the entire temporary traffic control zone, speed limit and REDUCED SPEED AHEAD, if applicable, signs shall be inserted in between the first and second advance warning signs at the prescribed sign spacing. If the reduced speed only applies to a specific section within the zone, the signing shall be placed in advance of the condition for which the reduced speed is deemed necessary at the prescribed sign spacing. Note: Speed

Limit and REDUCED SPEED AHEAD signs are not shown on the typical applications.

- For speed reductions greater than ten mph, additional notification should be provided through the use of the REDUCED SPEED AHEAD sign.

- For speed reductions greater than 20 mph, the speed limit should be reduced in two stages.

- On divided highways, the reduced speed is applicable to the affected direction of travel only.

- Existing speed limit signs within the temporary traffic control zone shall be covered or removed.

- Speed limit signs indicating the normal speed limit should be installed at the end of the reduced area provided no other reduction is imposed within the next one-half mile or no existing speed limit sign is located within the next one-half mile.

- Reduced speed limit signing shall be removed, covered, or turned from traffic when conditions requiring the reduced speed no longer exist.

- A special activity within a temporary traffic control zone may require a lower speed limit than the one imposed for the zone itself. The further reduced speed limit shall only be effective for the duration of that special activity and should comply with these guidelines.

Fine Signs

In an attempt to improve work zone safety, the legislature passed a bill in 2001 that provides for increased fines for speeding or speeding and passing in properly posted temporary traffic control zones. The required posting is accomplished though the installation of fine signs.

Fine signs provide the motorist with information on the amount of fine and for what action the fine will be assessed. As with other regulatory signs, these signs are most effective if they are properly applied and enforced. Furthermore, since fines are only applicable when workers are present, these signs shall be removed, covered, or turned from traffic when the condition no longer exists.

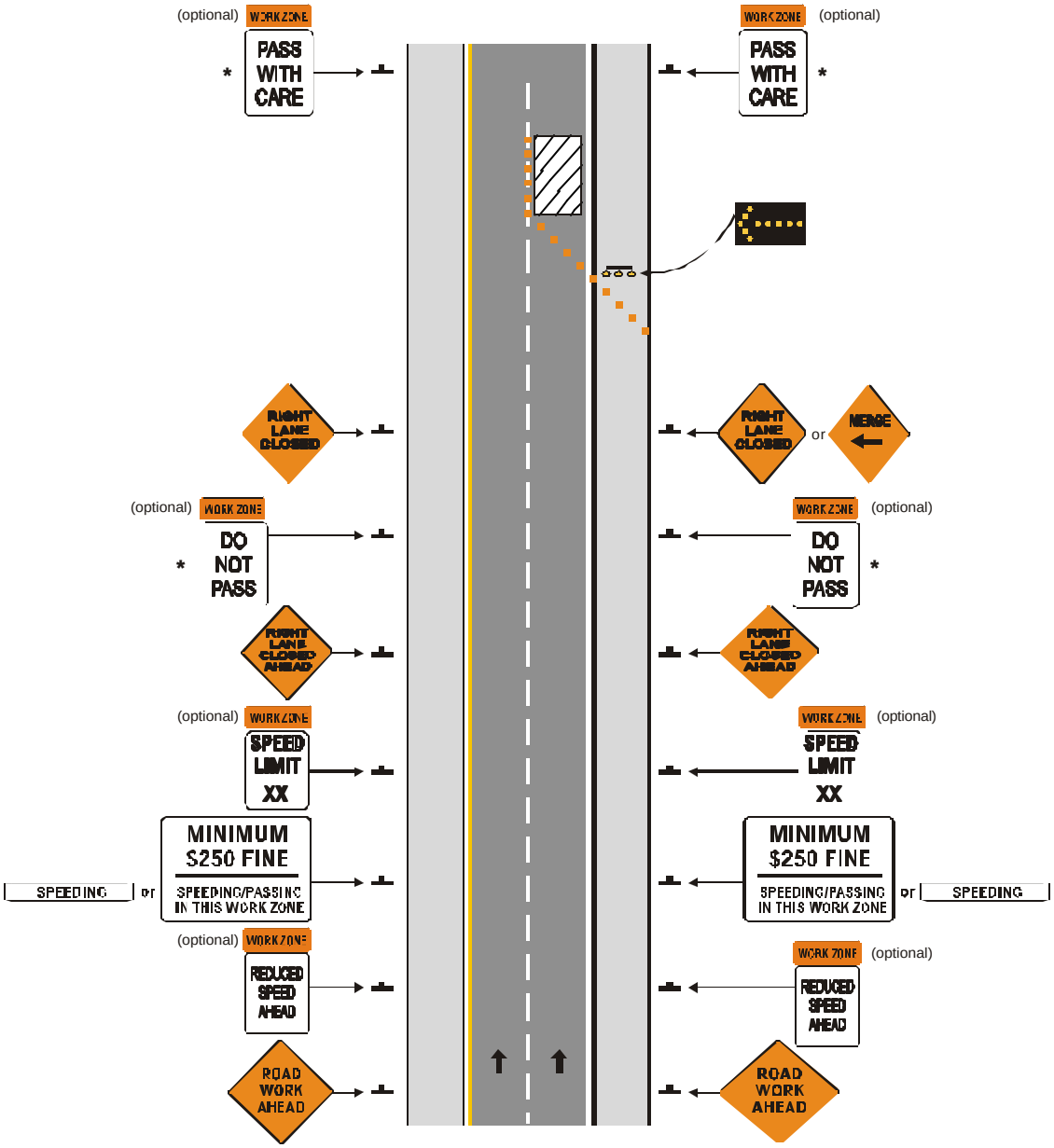
The implementation of the speeding portion of this provision may be considered when all four of the following criteria are met or where, upon the judgment of the supervisor, there is a need to control speed through the temporary traffic control zone.

- Work duration longer than 4 hours.

- Reduced speed limit in effect.
- Normal posted speed greater than or equal to 60 mph.
- Workers on roadway without barrier protection.

The implementation of the passing portion of this provision may be considered when, in addition to meeting the previous criteria or judgment, there is a lane drop on a multi-lane highway consisting of a maximum of two lanes in the affected direction.

When fine signs are used, their location, as well as other signing requirements, shall conform to the following illustration.



* Signs not used when only speeding portion of provision is invoked.

Railroads

When a highway-rail grade crossing exists within or upstream of the transition area and backups resulting from the lane closure might extend through the highway-rail grade crossing, the temporary traffic control zone should be extended so the transition area precedes the highway-rail grade crossing.

Excavations

When work activities involve movement of soil or subsurface operations, utilities shall be located by calling DIG-RITE, the local provider, and MoDOT.

Unprotected excavations or repairs located within the roadway shall be backfilled or plated while workers are not present. If plated, a sign indicating the plate is present shall be installed immediately adjacent to the location and along the edge of the road. During periods of possible ice and snow, the responsible party should convey the location of these sites to the appropriate MoDOT personnel.

Pavement Maintenance Operations

Following the completion of pavement maintenance operations projects such as leveling course, patching, seal coat, spot sealing, crack pouring, and scrub sealing, where the center line has been removed or interrupted for a distance of four skips, 160 feet for solid line, or more, temporary marking and signing shall be installed. Temporary marking and the placement of NO CENTER STRIPE signs shall be in accordance with Section 3 of the Marking section of the *Traffic Manual*.

When needed, FRESH OIL and LOOSE GRAVEL signs shall be incorporated into the advance warning signs at the prescribed sign spacing. FRESH OIL and LOOSE GRAVEL signs should also be installed on state highway approaches to the affected roadway or within 150 feet after the intersection and at one mile spacing throughout the affected area. Upon the discretion of the supervisor, additional FRESH OIL and LOOSE GRAVEL signs may be installed on other crossroad approaches to the affected roadway or within 150 feet after the intersection. The combination FRESH OIL/LOOSE GRAVEL sign may be used on low-volume approaches to the affected roadway.